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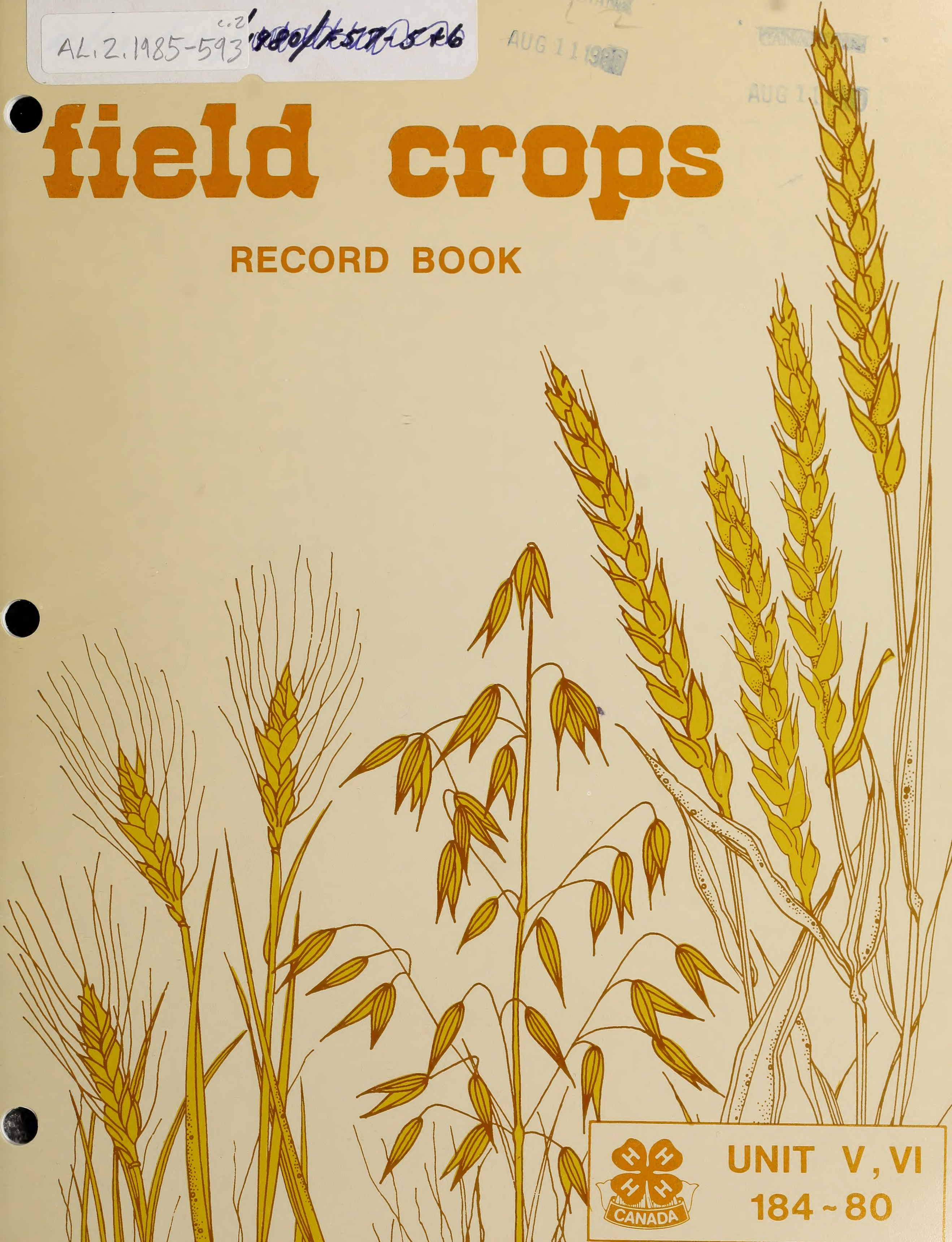

UNIT V, VI
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4-H MOTTO

"Learn to do by doing"

4-H PLEDGE

I pledge
My HEAD to clearer thinking,
My HEART to greater loyalty,
My HANDS to larger service,
My HEALTH to better living,
For my club, my community and my country

4-H GRACE

(Tune of Auld Lang Syne)

We thank thee, Lord, for blessings great
On this, our own fair land.
Teach us to serve thee joyfully,
With head, heart, health and hand.

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CANADA

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1. OBJECTIVES:

1. To demonstrate to the member the "economic theory of diminishing marginal returns", or in other words to demonstrate that: as you increase the amount of fertilizer you put on a crop, the additional return received or the response in yield increase, becomes smaller for each additional unit of fertilizer you add.

2. To demonstrate to the member the effects of: a lack of one nutrient (in this case N), and, an over abundance of one nutrient compared to a situation in which a balance of nutrients occurs.

3. To enable the member to learn:
    - fertilizer formulations
    - rates of application of actual nutrients
    - the effects upon a plant of an imbalance of nutrients
    - record keeping: costs and returns

2. DEFINITIONS YOU SHOULD KNOW:

SOIL - The unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

SURFACE SOIL - The uppermost part of the soil, ordinarily moved in tillage, or its equivalent in uncultivated soils and ranging in depth from 7-10 cm to 20-25 cm.

FERTILIZER - Any organic or inorganic material of natural or synthetic origin, which is added to a soil to supply certain elements essential to the growth of plants.

NUTRIENT - A chemical element essential for the growth and development of a organism.

NITROGEN FIXATION - The conversion of elemental nitrogen (N_2) to organic combinations or to forms readily utilizable in biological processes.

SOIL TILTH - The physical condition of the soil as related to its ease of tillage, fitness as a seedbed and its impedance to seedling emergence and cost penetration.

SOIL FERTILITY - The status of a soil with respect to the amount and availability to plants of elements necessary for plant growth.

MARGINAL COST - The cost of an additional increment or unit of fertilizer.

MARGINAL RETURN - The value of the increased yield which is a direct result of the additional fertilizer.

NET RETURN - Equal to gross returns minus total cost.

GROSS RETURN - Equal to the price times the yield.

GUARANTEED ANALYSIS - % by weight of N, P_2O_5 and K_2O in fertilizer. Labelled in that order.

3. FERTILIZER FORMULATIONS

Fertilizers are required by law to be labelled according to their guaranteed analysis in terms of percent by weight of nitrogen (N), phosphate (P_2O_5) and potash (K_2O). For example, 100 pounds of 11-55-0 contains 11 pounds of N, 55 pounds of P_2O_5 and 0 pounds of K_2O. This ration remains the same whether you are working with the British system (lb.) or with the metric system (kg.) a 100 kg bag of 11-55-0 would contain 11 kg of N and 55 kg of P_2O_5. More realistically, a 25 kg bag of 11-55-0 would contain 2.75 kg of N and 13.75 kg of P_2O_5. The most useful way of comparing costs of fertilizer is on the basis of the price per unit of nutrient, not price per unit of material.

For example:

i. if urea (46-0-0) costs \$170.00/ton, the cost per pound of N is:

$$2000 \text{ lb. X } \frac{46}{100} = 920 \text{ lb.}$$

$$\frac{\$170.00}{920 \text{ lb.}} = 18.5 \text{ cents/lb. of N}$$

ii. if Ammonium nitrate (34-0-0) costs \$130/ton the cost per pound of N is:

$$2000 \text{ lb. X } \frac{34}{100} = 680 \text{ lb.}$$

$$\frac{\$130.00}{680 \text{ lb.}} = 19.1 \text{ cents/lb. of N}$$

iii. if urea (46-0-0) costs \$187/tonne, the cost per kg of N is:

$$1000 \text{ kg X } \frac{46}{100} = 460 \text{ kg}$$

$$\frac{\$187.00}{460 \text{ kg}} = 40.7 \text{ cents/kg of N}$$

iv. if ammonium nitrate (34-0-0) costs \$143/tonne the cost per kg of N is:

$$1000 \text{ kg X } \frac{34}{100} = 340 \text{ kg}$$

$$\frac{\$143.00}{340 \text{ kg}} = 42.1 \text{ cents/kg of N}$$

4. RATES OF FERTILIZER APPLICATION

Similarily, rates of fertilizer application must be calculated in order to apply a given rate of nutrient. For example: if you want to apply 30 lbs. of phosphate (P_2O_5) you must apply 54.54 lb. of 11-55-0:

$$\frac{55}{100} = \frac{30}{X} \text{ or } \frac{3000}{55} = 54.54 \text{ lb.}$$

OR: If you want to apply 15 kg of P_2O_5 you must apply 27.27 kg of 11-55-0:

$$\frac{55}{100} = \frac{15}{X} \quad \text{or} \quad \frac{1500}{55} = 27.27 \text{ kg}$$

5. NUTRIENT SOURCES (for more detail see the Winter project manual Unit V)

Nitrogen (N)

1. Ammonium nitrate (34-0-0)
2. Ammonium sulphate (21-0-0-24S)
3. Urea (46-0-0)
4. Anhydrous ammonia (82-0-0)
5. Urea-Ammonium sulphate (34-0-0-11S)
6. Urea-Ammonium Nitrate Solutions (28-0-0 and 32-0-0)
7. Urea-Ammonium sulphate solution (20-0-05S)

Phosphorous (P)

1. Monoammonium phosphate (11-48-0, 11-54-0 and 11-55-0)
2. Diammonium phosphate (18-46-0)

Potassium (K)

1. Muriate of potash (0-0-60 or 0-0-62)

Sulphur (S)

1. Ammonium sulphate (21-0-0-24S)
2. Urea-Ammonium sulphate (34-0-0-11S)
3. Ammonium phosphate-sulphate (16-20-0-14S)
4. Urea-Ammonium sulphate solution (20-0-0-5S)

RATE OF FERTILIZER REQUIRED TO SUPPLY A GIVEN RATE OF NUTRIENTS

Fertilizer	kg/lbs. of Nitrogen (N) Required									
Formulation	10	20	30	40	50	60	70	80	90	100
21-0-0	48	95	143	190	238	286	333	381	429	476
34-0-0	29	59	88	118	147	176	206	235	265	294
46-0-0	22	44	65	87	109	133	156	178	196	217
82-0-0		24	37	49	61	73	85	98	110	122
27-14-0	37	74	111	148	185	222	259	296	333	370
23-23-0	44	87	130	174	217	261	304	347		
27-27-0	37	74	111	148	185	222	259	296		
18-46-0	55	110	165	222	278	333	389			
16-20-0	63	125	188	250	312	375				
17-34-0	59	117	176	235	294	353				

Fertilizer	kg/lbs. of phosphate (P_2O_5) Required									
Formulation	5	10	15	20	25	30	35	40	45	50
11-55-0	9	18	27	36	45	54	63	72	81	90
11-48-0	10	20	30	40	50	60	70	80	90	100
11-46-0	12	23	35	45	55	65	75	85	100	115
17-34-0	15	29	44	58	73	88	103	116	131	146
10-30-10	17	33	50	67	83	100	117	133	150	167
23-23-0	22	44	66	87	109	130	152	174	196	217
16-20-0	25	50	75	100	125	150	175	200	225	250
27-14-0	36	71	107	143	179	214				
8-24-24 6-24-24	21	42	63	83	104	125	146	167	188	208

Fertilizer	kg/lbs. of Potash (K_2O) Required									
Formulation	5	10	15	20	25	30	35	40	45	50
0-0-60 0-0-62	8	17	25	33	42	50	56	68	72	85
10-30-10	50	100	150	200	250	300				
8-24-24 6-24-24	20	40	60	80	100	125	140	160	180	200
13-13-13	38	77	115	153	192	230				
14-14-78	72	144	216							

Fertilizer	kg/lbs. of Sulphur (S) Required					
Formulation	5	10	15	20	25	30
21-0-0(24%S)	20	40	60	80	100	120
16-20-0(14%S)	36	71	107	143	180	
34-0-0(11%S)	48	95	140			
10-30-10(5%S)	100	200				
Gypsum (18%S)	27	55	82	110	137	165
Agri-Sul (90%S)			17	22	28	33

6. ASSESSING RETURNS FROM FERTILIZER

When using the same estimates of increase in yield from fertilizer "net returns" or the value of the increased yield minus the cost of the fertilizer were higher in 1975 than in 1970. Why? The reason is, of course, because of the crop and fertilizer price relationship. In 1970 net returns were higher for rapeseed than for wheat, barley or oats but in 1975 net returns were similar for all four crops. Why? The reason here is because of the relationship between the prices of the different crops.

Comparing returns based on present and past fertilizer and crop prices can be a useful tool when choosing your fertilizer program. The following table converted from the Alberta Soils Advisory Committee, Alberta Fertilizer Guide (1) shows such comparisons at two different levels of fertilization. The economic theory of diminishing marginal returns states that as you increase the amount of input (in this case fertilizer), the response in yield or additional return received becomes smaller.

The best method of selecting a fertilizer rate is to compare "marginal costs" and "marginal returns" over a range of application rates. Marginal costs is the cost of the additional fertilizer. In the following table (next page) the marginal or additional cost is the cost of 22.4 kg/hectare of nitrogen (or the cost of the difference in fertilizer rates, 67 kg/ha compared to 45 kg/ha). The marginal cost, of course, is different in each year because of the difference in costs of fertilizer.

Marginal return is the value of the increase in yield from the additional fertilizer. For example: for wheat in 1970, the value of the increased yield was:

0.935 tonnes - 0.693 tonnes = 0.242 tonnes
0.242 tonnes X $47.77/tonne = $11.56/hectare

The marginal cost in 1970 for wheat was 22.4 kg X $.24/kg = $5.38/hectare. So, in this case the marginal return was twice the marginal cost.

EFFECT OF FERTILIZER AND CROP PRICES ON RETURNS FROM FERTILIZER

CROP	PRICE PER TONNE	INCREASE IN YIELD FROM FERTILIZER* 1	INCREASE IN YIELD FROM FERTILIZER* 2	VALUE OF INCREASED YIELD 1	VALUE OF INCREASED YIELD 2	FERTILIZER COST 1	FERTILIZER COST 2	NET RETURNS 1	NET RETURNS 2	MARGINAL COSTS	MARGINAL RETURNS
WHEAT											
1970	$ 47.77			$33.09	$ 44.65	$15.79	$21.19	$17.30	$23.46	$5.38	$11.56
		0.693	0.935								
1975	128.60			89.12	120.24	26.60	35.56	62.52	84.68	8.96	31.12
BARLEY											
1970	36.74			34.20	44.28	15.79	21.19	18.41	23.09	5.38	10.07
		0.931	1.205								
1975	91.86			85.52	110.69	26.60	35.56	58.92	75.13	8.96	25.17
OATS											
1970	32.42			30.51	39.54	15.79	21.19	14.72	18.35	5.38	9.01
		0.941	1.219								
1975	90.78			85.42	110.66	26.60	35.56	58.82	75.10	8.96	25.24
RAPESEED											
1970	121.25			46.20	62.44	15.79	21.19	30.41	41.25	5.38	16.25
		0.381	0.515								
1975	220.46			83.99	113.54	26.60	35.56	57.39	77.98	8.96	29.54

Fertilizer prices used: 1970 - Nitrogen $.24/kg Phosphate $.18/kg
1975 - Nitrogen .40/kg Phosphate .31/kg

1* - 44.8 kg/ha of nitrogen and 28 kg/ha of phosphate
2* - 67.2 kg/ha of nitrogen and 28 kg/ha of phosphate

If you add additional fertilizer beyond the point where marginal costs equal marginal returns, it will cost more than the value of the increased yield. Maximum net returns per hectare can be achieved when marginal costs equal marginal return, however, because of the risks involved in crop production and in price uncertainties, it may be wise to choose a lower level of fertilization. Another thing to consider if you are short of operating capital (money), is additional dollars spent on fertilizer may return you less than if the money were spent on other production inputs such as weed control. This situation would illustrate the economic theory of equi-marginal returns which states that available capital should be distributed among the various inputs in such a way that returns per unit of capital invested in each input are equal. This can also be applied to various farm enterprises, for example feeding cattle compared to growing wheat. Additional units of capital put into growing wheat may offer a higher return if they were used to feed cattle.

7. SUGGESTED PLOT GUIDELINES

1. Members are to seed a 1 hectare plot to either a cereal grain, oilseed, grass, legume or a mixture, at one rate but in 1/4 hectare strips with one meter between each strip that is to be kept black. If a member wishes to do the optional Unit VI, he might want to underseed forages with a cereal grain this year.
2. Members should have taken a soil sample in the fall of the previous year, sent it in to be analyzed and have received the soil test report. The rates of N, P, K, and S that are already present in the soil should be noted, as well as the recommended rates of (N), (P_2O_5), (K_2O) and (S). This will give you a good idea of the total nutrients available to the plants in the test.
3. ***NOTE:** Anyone who is planning on using a legume or a mixture containing a legume such as alfalfa, should substitute phosphate (P_2O_5) for nitrogen in the following guidelines. This is because of the inherent ability of legumes to "fix" nitrogen from the air thus supplying nitrogen to the plants. Legumes seed should also be inoculated with the proper bacteria. (See your local seed store or feedmill for inoculum.)
4. P_2O_5, K_2O and S should be applied at the recommended rates across the whole of the plot.
5. Nitrogen should be applied (broadcast) on the 1/4 hectare strips at the following rates:

Control - 0 kg/hectare
Strip #1 - a low rate 34 kg/hectare
Strip #2 - double the firt rate 68 kg/hectare
Strip #3 - double the second rate 136 kg/hectare

***NOTE:** Ammonium Nitrate, 34-0-0 contains 8.5 kg of nitrogen/25 kg bag of fertilizer.

If you need to apply phosphorus in the form of 11-48-0 or 11-55-0 this will affect the amount of nitrogen which you are applying since both these fertilizers contain 11% N by weight. This simply means your rates of N will be somewhat larger. It will not affect your results, but you will need to know the total amount of N applied per hectare in order to figure out your costs and returns per additional unit of N added.

6. Accurate records should be kept on: Fertilizer application rates, growth of the plants, yields, costs and returns.
7. We suggest that the easiest way to apply the fertilizer is to broadcast it by hand as evenly as you can.

8. PHYSICAL RECORDS

1. Kind of crop (cereal, grass, legume, oilseed or specialty crop)

   ____

2. Species ____________________
   Variety ____________________

3. Fertilizer formula or formulas being used ______________

   ____

   Control: no fertilizer
   Strip #1 1) kg/ha of nitrogen ______________
   2) kg/ha of P_2O_5 (phosphate)______________
   3) others ______________
   Strip #2 1) kg/ha of nitrogen ______________
   2) kg/ha of P_2O_5 (phosphate)______________
   3) others ______________
   Strip #3 1) kg/ha of nitrogen ______________
   2) kg/ha of P_2O_5 (phosphate)______________
   3) others ______________

4. Soil and Feed Testing Laboratory recommendations.
   Nitrogen (N) ____________________kg/ha
   Phosphate (P_2O_5)____________________kg/ha
   Others ____________________kg/ha

   If the soil test report indicates a need for any other nutrient (i.e. sulphur), you should try to satisfy this need consistently across the whole plot.

5. Date seeded ____________________

6. Record of growth (cm)

	CONTROL	STRIP #1	STRIP #2	STRIP #3
Date of emergence				
Height at 2 weeks				
Height at 4 weeks				
Height at 6 weeks				
Height at 8 weeks				
Height at Maturity				
Days-seeding to Maturity				

7. Diseases, weeds, insects which affected the plot.

Control: ______________________________

____

____

Strip #1: ______________________________

____

____

Strip #3: ______________________________

____

____

8. Yield, as close as possible.

Control: ______________ kg/ha ______________ tonnes/ha
Strip #1: ______________ kg/ha ______________ tonnes/ha
Strip #2: ______________ kg/ha ______________ tonnes/ha
Strip #3: ______________ kg/ha ______________ tonnes/ha

9. Quality of seed or hay: relative (excellent, good, poor)

Control: ______________
Strip #1: ______________
Strip #2: ______________
Strip #3: ______________

9. COSTS & RETURNS OF NITROGEN

A. RETURNS

Gross Returns/hectare

Control: $________________/tonne $________________/hectare
Strip #1: $________________/tonne $________________/hectare
Strip #2: $________________/tonne $________________/hectare
Strip #3: $________________/tonne $________________/hectare

Remember if your Strips are each 1/4 hectare you must multiply by 4 to get results on a per hectare basis.

B. TOTAL COST/HECTARE

1. Control

	COST PER HECTARE
Overhead or fixed costs:	
a) Rent of land ________________	$____________
b) Taxes and water rates (if applicable)	$____________
Operating Costs:	
c) Cost of Seed__________kg at $_______per/kg	$____________
d) Cost of material for seed treatment	$____________
e) Cost of fertilizer ____________tonnes at $______________tonne	$____________
f) Cost of chemical used for weed control	$____________
g) Cost of pest control	$____________
h) Cost of Custom Work	
Fall tillage	$____________
Seedbed preparation	$____________
Seeding	$____________
Spraying	$____________
Swathing	$____________
Combining	$____________
Hauling	$____________
i) Other Costs (specify)	
____	$____________
TOTAL COST PER HECTARE	$============

2. Strip #1
    a-i) Same as preceding page

3. Strip #2
    a-i) Same as preceding page

4. Strip #3
    a-i) Same as preceding page

C. NET RETURNS/HECTARE

Net returns = gross returns - total costs
Control: $____________________/hectare
Strip #1: $____________________/hectare
Strip #2: $____________________/hectare
Strip #3: $____________________/hectare

D. RETURNS TO NITROGEN

Return per additional kg of N used equals:

> Increase in yield X price/unit ÷ increase in the number of units of nitrogen used = return/additional unit of N.

Example: Bob's test strip #1 had a yield of 2050 kg or 0.93 tonnes of wheat per hectare and his test strip #2 had a yield of 2730 kg or 1.24 tonnes of wheat per hectare. He put 100 kg/hectare of 34-0-0 and 100 kg/hectare 11-48-0 on test strip #1. He put 200 kg/hectare of 34-0-0 and 100 kg of 11-48-0 on test strip #2. (Remember if Bob's test strip is 1/4 hectare, he actually put only 1/4 of these figures on each test strip.) The price of wheat is $150.00/tonne. The return per additional unit of nitrogen for test strip #2 is:

> 1.24 tonnes/hectare - 0.93 tonnes/hectare =
>
> 0.31 tonnes/hectare
>
> 0.31 X $150/tonne ÷ (68+11) - (34+11)=price/-additional kg of fertilizer
> $46.5 ÷ (79-45) = $1.37/additional kg of fertilizer

Returns per additional kg of nitrogen per hectare

Strip #1 ______________________kg of N per hectare
Strip #2 ______________________kg of N per hectare
Strip #3 ______________________kg of N per hectare

E. COST OF NITROGEN

Costs per additional kg of nitrogen used equals the cost per unit of nitrogen.
Example: If 34-0-0 is worth $161.34/tonne. However, we need the cost of 1 kg of nitrogen. One tonne of 34-0-0 contains 340 kg of nitrogen. Therefore, the cost of 1 kg of nitrogen equals:

$$\frac{\$161.34}{340 \text{ kg of N}} = \$0.47/\text{kg of N}$$

The cost remains the same of course for each additional kg of nitrogen. However, as the amount of nitrogen goes down. When the return per additional kg of nitrogen drops below $0.47 per kg of nitrogen, it is no longer economical to put more nitrogen on the crop even though you may get an increased yield from application of more nitrogen.
Strips #1, #2, #3, $______________/additional kg of nitrogen

F. MARGINAL RETURNS

Marginal returns per hectare to additional nitrogen equals:

increased yield/hectare X price/unit

Example: The marginal return per hectare in Strip #2 as in D Section on preceding page is:

0.31 tonnes X $150.00 tonne = $46.50

Strip #1 $______________________per hectare
Strip #2 $______________________per hectare
Strip #3 $______________________per hectare

G. MARGINAL COST

Marginal cost per hectare of additional nitrogen equals:

cost/unit of nitrogen X additional nitrogen/hectare

or

$0.47/kg X additional nitrogen

Example: The marginal cost as in D Section preceding page is:

$0.47/kg X 34 kg = $15.98

Strip #1 $________________________per hectare
Strip #2 $________________________per hectare
Strip #3 $________________________per hectare

10. SUMMARY Strip #1

A. Did you observe a significant or noticeable difference between control and fertilized plots with respect to the following growth characteristics:

	YES	NO
a. color of plants	____	____
b. height of plants	____	____
c. stooling	____	____
d. apparent head size	____	____
e. filling of heads	____	____
f. resistance to lodging	____	____
g. days to maturity	____	____

NOTE: A difference of more than one day may be considered significant.

B. Please comment further on those characteristics in which you noticed significant differences between control and fertilized plots. Tell whether the difference was barely or quite readily noticeable. Also mention any detrimental rather than beneficial effects which fertilization had. Speculate as to why these differences might have occurred.

10. SUMMARY Strip #2

A. Did you observe a significant or noticeable difference between control and fertilized plots with respect to the following growth characteristics:

	YES	NO
a. color of plants	____	____
b. height of plants	____	____
c. stooling	____	____
d. apparent head size	____	____
e. filling of heads	____	____
f. resistance to lodging	____	____
g. days to maturity	____	____

NOTE: A difference of more than one day may be considered significant.

B. Please comment further on those characteristics in which you noticed significant differences between control and fertilized plots. Tell whether the difference was barely or quite readily noticeable. Also mention any detrimental rather than beneficial effects which fertilization had. Speculate as to why these differences might have occurred.

10. SUMMARY Strip #3

A. Did you observe a significant or noticeable difference between control and fertilized plots with respect to the following growth characteristics:

		YES	NO
a.	color of plants		
b.	height of plants		
c.	stooling		
d.	apparent head size		
e.	filling of heads		
f.	resistance to lodging		
g.	days to maturity		

NOTE: A difference of more than one day may be considered significant.

B. Please comment further on those characteristics in which you noticed significant differences between control and fertilized plots. Tell whether the difference was barely or quite readily noticeable. Also mention any detrimental rather than beneficial effects which fertilization had. Speculate as to why these differences might have occurred.

10. CONCLUSIONS

A. Did you reach the point where marginal cost equals marginal return? If so, approximately where?

B. What did this unit tell you about rates of fertilizer application?

11. THE STORY OF MY PLOT

This space is provided for the story of your project. As well as telling the story of your plot, state what, if anything, you learned from this year in 4-H. Be sure to mention the optional projects you undertook in addition to the plot. Include pictures if you have them.

METRIC CONVERSION TABLE

Commonly Used Metric Measures

1 kilometer (km) =1,000 meters
1 square hectare (ha) =10,000 square meters
1 metric ton (tonne) =1,000 kilograms
1 kilogram (kg) =1,000 grams

Converting Metric Measures to English

1 hectare (ha) =2.47 acres
1 kilometer (km) =0.62 miles
1 meter (m) =1.09 yards or 3.28 feet
1 centimeter (cm) =0.39 inches
1 kilogram (kg) =2.2 pounds
1 tonne (t) =1.1 tons or 2204 pounds
1 tonne (t) =36.74 bu. of wheat
=45.83 bu. of barley
=64.84 bu. of oats
=44.09 bu. of rapeseed
=39.37 bu. of rye
=39.37 bu. of flax
1 litre (l) =0.22 gallons
1 kilowatt (kw) =1.34 horsepower

Converting English Measure to Metric

1 acre =0.405 hectares
1 mile =1.61 kilometers
1 foot =0.30 meters
1 inch =2.50 centimeters
1 pound =0.45 kilograms
1 ton =0.91 tonnes
1 bu. of wheat =27.30 kilograms
1 bu. of barley =21.80 kilograms
1 bu. of oats =15.50 kilograms
1 bu. of rapeseed =22.70 kilograms
1 bu. of rye =25.20 kilograms
1 bu. of flax =25.20 kilograms
1 horsepower =.75 kilowatts

Other Conversions You Should Know

1 bu. wheat =60 lb.
1 bu. oats =34 lb.
1 bu. barley =48 lb.
1 bu. rape =50 lb.
1 bu. rye =56 lb.
1 bu. flax =56 lb.

1 kilogram per hectare =0.89 lbs. per acre (approx.)
1 pound per acre =1.12 kilograms per hectare (approx)

If a fertilizer recommendation is given in kilograms per hectare and the machine is calibrated in pounds per acre, set the machine at 10% less than the recommendation and you will obtain the rate that is required.

SOURCES

1. Alberta Soil Advisory Committee, Alberta Fertilizer Guide, Agdex 541-1, published by Alberta Agriculture, 1976.
2. Hausenbuiller, R. L., Soil Science, Principles and Practices, W. C. Brown Company Publishers, 1972.

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Alberta

AGRICULTURE
4-H BRANCH